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TITLE: DIFFERENTIATED SERVICE BASED QoS IN WiMAX

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ABSTRACT

The demand for broadband wireless services is growing very sharply nowdays due to its Unique advantages as compared to wired technology like high speed , rapid deployment, flexible, efficient and cost effective. WiMAX (IEEE 802.16) is such one of the most popular broadband wireless access technology which defines a high bandwidth, long – range technology with aggregate bandwidth covering a larger area. As quality of service (QoS) has become an important factor in networking and WiMAX network includes the QoS mechanism in Medium Access Control (MAC) layer architecture. The various QoS parameters like packet loss, throughput, average jitter and average delay are analyzed by applying the Differentiated service (Diffserv) architecture well defined by IETF. The Diffserv model defines the use of differentiated service code point(DSCP) and four per-hop-behaviors (PHBs). So, the scheduling or queuing algorithms will be studied and it has been observed that mainly the two scheduling algorithms i.e. Low Latency Queuing (LLQ) and Class Based Weighted Fair Queuing (CBWFQ) disciplines will be used for defining the various QoS parameters on the traffic like voice, video and best effort with the help of DSCP values in WiMAX networks. In the analysis, a WiMAX module will be developed based on popular network simulator ns-2, used. Various real life scenarios like voice, call, video streaming will be setup in the simulation environment.

Keywords: WiMAX, QoS, Diffserv, PHBs, DSCP, LLQ, CBWFQ

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1. INTRODUCTION:

1.1 WiMAX (IEEE 802.16)

WiMAX (World-Wide-Interoperability for Micriwave Access) is the IEEE 802.16 Wireless MAN technology which is intended to be the leading wireless technology for broadband access in the 10-66 GHz range which supports Line-of-sight operation. Similarly this standard was enhanced to include deployment of Non-line-of-sight operation in the 2-11GHz range which added orthogonal frequency division multiplexing(OFDM) in the physical layer. WiMAX network has a range of 30 miles with in a typical cell radius of 4-6 miles having channel sizes range from 1.5 to 20 MHz.

The IEEE 802.16 standard consists of two core components i.e. the Base Station (BS) and Service Station(SS). A point-to-multipoint(P2MP) structure may consist of a base station and one or more service stations which form a cell. Multiple base stations can be configured to form a cellular wireless network . In communication on air, the base station(BS) control activity with in the cell which includes access to the medium by any service station(SS) and allocation to achieve quality of service(QoS) with admission to the network based on various security mechanisms. WiMAX uses either Time-division duplex(TDD) or Frequency-division duplex(FDD) techniques for downlink (from BS to SS) and uplink (from SS to BS).

Communication for exchange of information in WiMAX, time is divided into frame can vary from 0.5 msec to 20 msec. Further frame is divided into a downlink subframe and uplink subframe. Each subframe is again subdivided into a fixed number of slots . A subscriber station transmits data in specific slots designated by the base station. A slot denotes a unit of transmission bandwidth. Quality of service(QoS) and transmission are achieved by allocating the slots to various service stations by considering the need of applications as voice needs delay/jitter and FTP needs high bandwidth.

1.2 Quality of Service (QoS)

QoS refers to ability of a network to provide improved service to selected network traffic either it uses wire based or wireless based technologies .QOS helps a network to reduce the loss characterstics, support dedicated bandwidth, less network congestion, shapes well network traffic and setting network priorities across the network. QoS can also be defined a something a FLOW seeks to attain.

QoS mechanism does not create an additional bandwidth for the selected network instead it uses the available bandwidth in a way that the network can provide the maximum requested QoS with the maximum bandwidth available for that traffic during the session. The network traffic is selected based on classification of packets so that some packets flows can be treated better than others. QoS in wireless networks is handled at Medium access control (MAC) layer.

1.3 QoS Performance Metrices

The transmission quality of the network is determined by various following parameters:

Average Delay or Latency:

Delay or Latency would be time taken by the packets to travel from the source to the destination . The main source of delay can be further classified into propogation delay, network delay, source-processing delay and destination processing delay. The average delay or latency can be calculated as

$$\text{Latency} = \frac{\text{Packet Arrival} - \text{Packet Start}}{n}$$

Jitter or Delay Variation :

It is the variation in the delay introduced by the components along the communication path. It is the variation in the time between packets arriving. Jitter is commonly used as indicator of consistency and stability of a network. Average jitter can be calculated by

Packet loss or Corruption Rate:

It affects the perceived quality of the application. This is a quantity that can be measured by the network analysis tools and this quantity is the percentage of packets that are sent from one end of the network connection that do not reach the other end. Packet loss increases due to congestion.

Throughput or Bandwidth:

It is a measure of the data rate (bits per second) generated by the application. In addition to above parameters WiMAX also follow other guidelines to maintain proper QoS provisioning. WiMAX networks are prone to high delay figures and high error rates due to the nature of the communication medium i.e. Air. So performance will also be greatly affected due to the process latency, inefficiency in radio source management and channel access mechanisms can become a bottleneck in high speed networks.

2. WiMAX QoS Architecture

The IEEE 802.16 standard specifies the five QoS classes as shown in following table:

Class	Description	Minimum Rate	Maximum Rate	Latency	Jitter	Priority
1) UGS	VOIP, EI, Fixed size packets on periodic basis	-	Y	Y	Y	-
2) rtPS	Streaming audio/video	Y	Y	Y	-	Y
3) ErtPS (enhanced)	VOIP with activity detection.	Y	Y	Y	Y	Y
4) NrtPS	FTP	Y	Y	-	-	Y
5) BE	Data transfer Web browsing etc.	-	Y	-	-	Y

Unsolicited Grant Service (UGS):

It is designed to support real time services flows that generate fixed data packet on a periodic basis such as voice over IP (VOIP) traffic. The service offers fixed size unsolicited data grants on a periodic basis. In UGS contention-based access is not allowed.

Real Time Polling Service (rtPS) flows:

It is designed to support real-time service flows that generate variable-size data packets on a periodic basis such as streaming video with silence suppression on a periodic basis.

Enhanced Real Time Polling(ertPS) flows:

It is specified in 802.16e and will be used for VOIP services with variable packet sizes as opposed to fixed packet sizes where silence suppression is used.

Non Real Time Variable Rate (nrtPS) flows:

It is designed to support non real-time service flows that require variable-size data grants on a regular basis such as high bandwidth file transfer protocol. The service offers unicast request opportunities on a periodic basis but using more spaced intervals than rtPS. This ensures that the flow receives request opportunities even during network congestion.

Best Effort :

It is the old standby technique for web surfing in internet. This service is maintained by allowing the SS to use contention request opportunities. This result in the SS using contention request opportunities as well as unicast request opportunities and unsolicited data grant burst types.

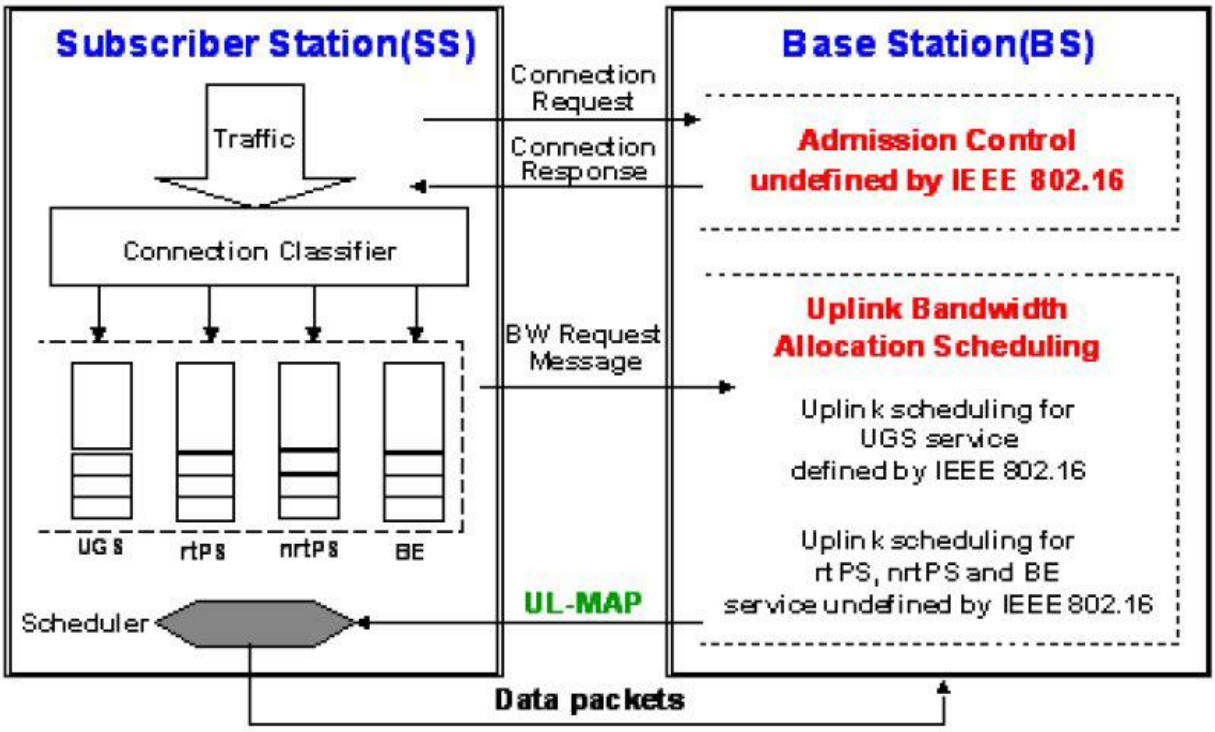
QoS Models for WiMAX

Today's network applies best effort (BE) IP forwarding. Although BE work remain good for most applications but QoS support is required to satisfy the growing need for VOIP, multimedia and other applications.

To facilitate end to end QoS on an network the Internet Engineering Task Force (IETF) has defined two QoS models : Integrated Services(IntServ) and Differentiated Services (Diffserv). Intserv framework provides explicit reservations end to end and Diffserv architecture offers hop-by-hop differentiated treatment of packets.

Differentiated Service Architecture

The diffserv architecture provides a framework within which service providers can offer customers a range of network services, each differentiated basd on performance. With Diffserv (DS) ,traffic is divided into a small number of groups called forwarding class. Each Forwarding class represents a predifned forwarding treatment in terms of drop priority and bandwidth allocation.A user can choose the performance level needed on a packet-by-packet basis by simply marking the packet's Differentiated Services Code Point (DSCP) field to a specific value.



Diffserv works on following principles:

1. Resource allocation to aggregated traffic rather than individual flows.
2. Traffic policing on the edge and class- based forwarding in the core.
3. This standard define forwarding treatments rather than a service.
4. Provide resource assurance or guarantee by provisioning rather than reservation.
5. Emphasis on service level agreements rather than dynamic signaling.
6. Focuses on a single domain.

In order to deliver end-to-end QoS, Diffserv architecture[RFC-2475] has two major components i.e.

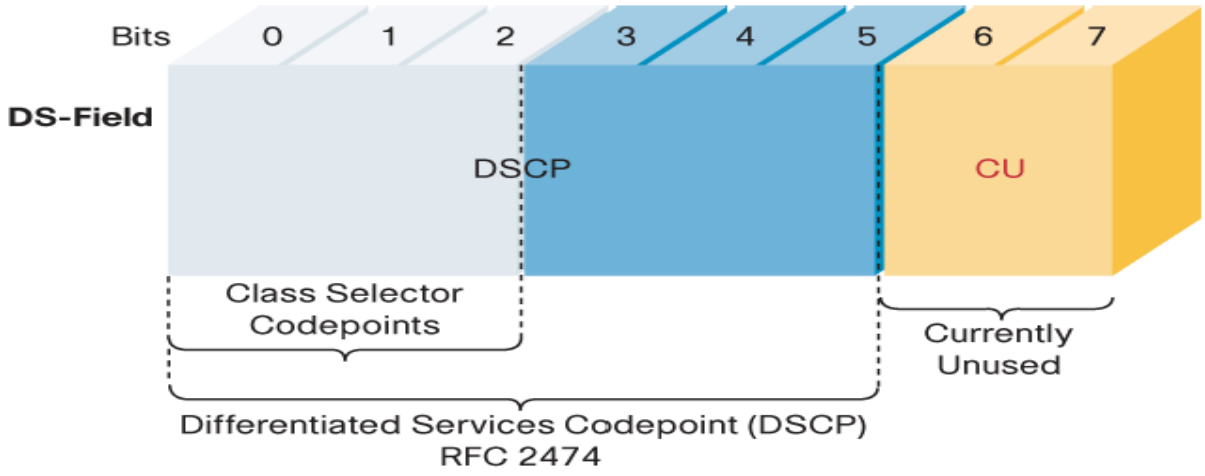
--- Packet Marking

--- Per Hop Behaviors

Packet Marking:

It is carried out by the Differentiated Services field(DS) having Differentiated Service Code Point(DSCP) as shown in figure in which six bits are used to classify packets to select Per-Hop-Behavior(PHB) at each interface.

In my research work DSCP VALUES will play an important role for selecting the appropriate PHB's.



PER-HOP BEHAVIORS:

After marking the packets, the packets having same DSCP value to be collected and to be sending in a particular direction is called as a Behavior Aggregates(BA).Packets from multiple applications/sources could belong to the same BA.

RFC -2475 defines PHB as the externally observable forwarding behavior applied to a DS-compliant node to a DS-BA.

So the following four PHB's will be used in my research work for Packet Scheduling, Queuing, Policing or Shaping behavior of a node on any given packet belonging to a BA for attaining the required QoS.

The Default PHB [RFC- 2474]

In research work the Default PHB having a packet marked with a DSCP value (recommended) of '000000' will get the traditional Best Effort Service from a DS-Compliant node . Also If a packet arrives, a DS-Compliant node and its DSCP value is not mapped to any other PHB's, it will get mapped to the Default PHB.

Class Selector PHB [RFC- 2474]

To preserve backward compatibility with the IP-precedence scheme, DSCP values of the form 'xxx000,' where x is either 0 or 1, are defined. These code points are

called class-selector code points. Note that the default code point is also a class-selector code point (‘000000’). The PHB associated with a class-selector code point is a class-selector PHB. These PHBs retain almost the same forwarding behavior as nodes that implement IP-precedence based classification and forwarding.
For example, with a DSCP value of ‘110000’ (IP-precedence 110) have a preferential forwarding treatment (scheduling, queuing, etc.) as compared to packets with a DSCP value of ‘100000’ (IP-precedence 100). These PHBs ensure that DS-compliant nodes can co-exist with IP-precedence aware nodes.

Expedited Forwarding PHB [RFC-2598]

The Expedited Forwarding (EF) PHB is the key ingredient in DiffServ for providing a low-loss, low-latency, low-jitter, and assured bandwidth service. Applications such as VoIP, video, and online trading programs require a robust network-treatment. EF can be implemented using priority queuing, along with rate limiting on the class (formally, a BA). Although EF PHB when implemented in a DiffServ network provides a premium service, it should be specifically targeted toward the most critical applications, because if congestion exists, it is not possible to treat all or most traffic as high priority. EF PHB is especially suitable for applications(like VoIP) that require very low packet loss, guaranteed bandwidth, low delay and low jitter. The recommended DSCP value for EF is ‘101110’(RFC-2474).

Assured Forwarding PHB [RFC-2597]

Assured Forwarding (AF) PHB is nearly equivalent to Controlled Load Service available in the integrated services model. An AF PHB defines a method by which BAs can be given different forwarding assurances.

For example, network traffic can be divided into the following classes:

- Gold: Traffic in this category is allocated 50 percent of the available bandwidth.

- Silver: Traffic in this category is allocated 30 percent of the available bandwidth.
- Bronze: Traffic in this category is allocated 20 percent of the available bandwidth.

Further, the AF PHB defines four AF classes: AF1, AF2, AF3, and AF4. Each class is assigned a specific amount of buffer space and interface bandwidth, according to the SLA with the service provider or policy map.

Within each AF class, we can specify three drop precedence (dP) values: 1, 2, and 3.

In my research work Assured Forwarding PHB can be expressed as follows:

AFny

In this example, n represents the AF class number (1, 2, 3, or 4) and y represents the dP value (1, 2, or 3) within the AFn class.

In instances of network traffic congestion, if packets in a particular AF class (for example, AF1) need to be dropped, packets in the AF1 class will be dropped according to the following guideline:

dP(AFny) >= dP(AFnz) >= dP(AFnx)

where dP (AFny) is the probability that packets of the AFny class will be dropped. In other words, y denotes the dP within an AFn class.

In the following example, packets in the AF13 class will be dropped before packets in the AF12 class, which in turn will be dropped before packets in the AF11 class:

dP(AF13) >= dP (AF12) >= dP(AF11)

The dP method penalizes traffic flows within a particular BA that exceed the assigned bandwidth. Packets on these offending flows could be re-marked by a policer to a higher drop precedence.

An AFx class can be denoted by the DSCP value, xyzab0, where xyz can be 001, 010, 011, or 100, and ab represents the dP value.

The following table having the list of DSCP values and corresponding dp values for each AF PHB class will be used in my research work.

Drop Precedence	Class 1	Class 2	Class 3	Class 4
Low Drop Precedence	(AF11)001010	(AF21)010010	(AF31)011010	(AF41)100010
Medium Drop Precedence	(AF12)001100	(AF22)010100	(AF32)011100	(AF42)100100
High Drop Precedence	(AF13)001110	(AF23)010110	(AF33)011110	(AF43)100110

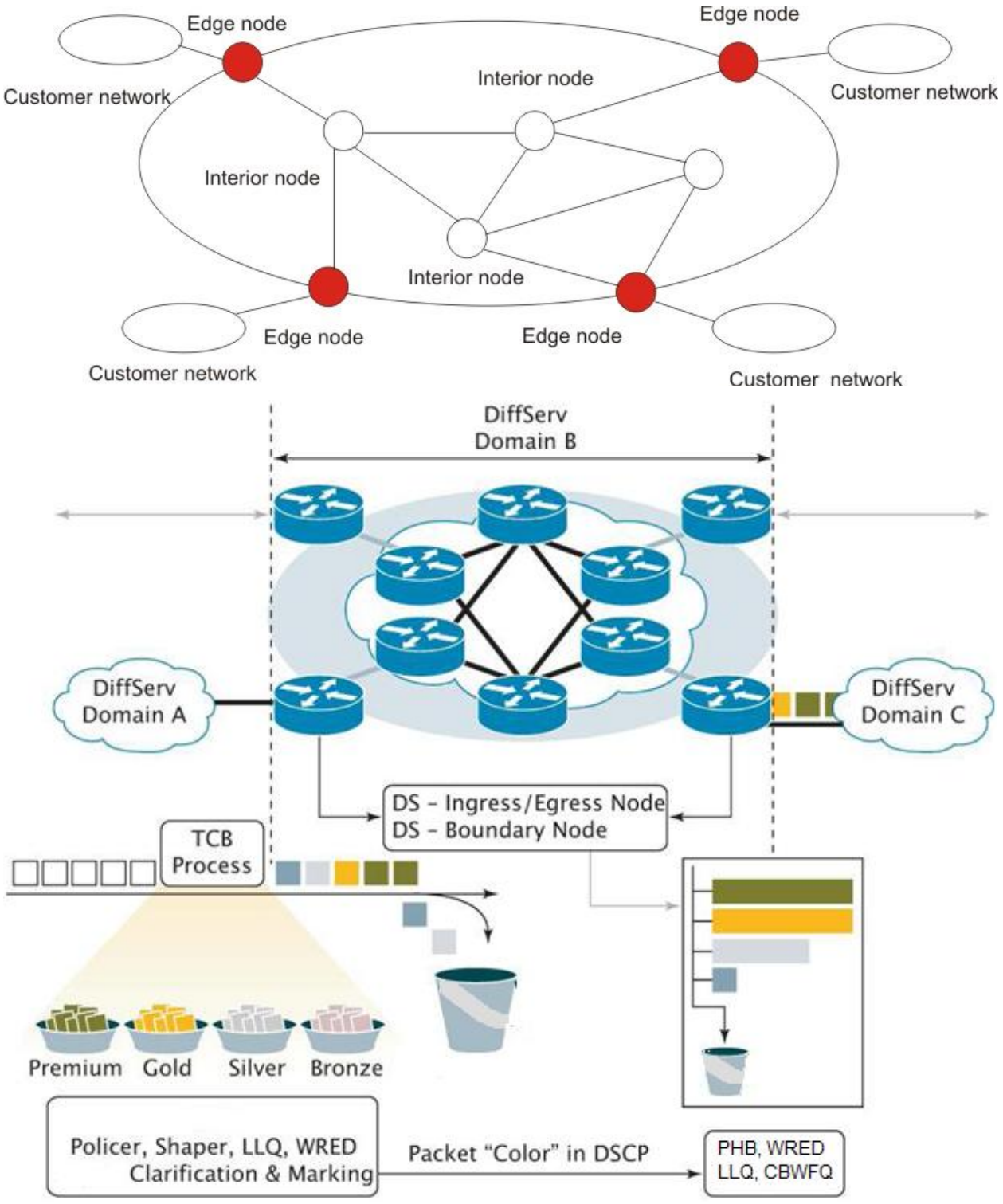
3. IMPLEMENTATION

The DiffServ in WiMAX wiil be applied to a DS-region which is composed of one or more DS-domains, possibly under multiple administrative authorities. Each DS-domain will be prepared by using the DSCP and the different PHBs.

The following figure gives a overview of this end-to-end architecture. For true QoS, the entire IP path that a packet travels must be DiffServ enabled.

In this the Expedited forwarding ----- 10 % ; Gold ----- 40 %
Silver ---- 30% ; bronze ----- 10% ; Best Effort----- 10%
will share the total of the bandwidth where as Gold,Silver and bronze will be mapped to AF classes AF1, AF2 and AF3 .

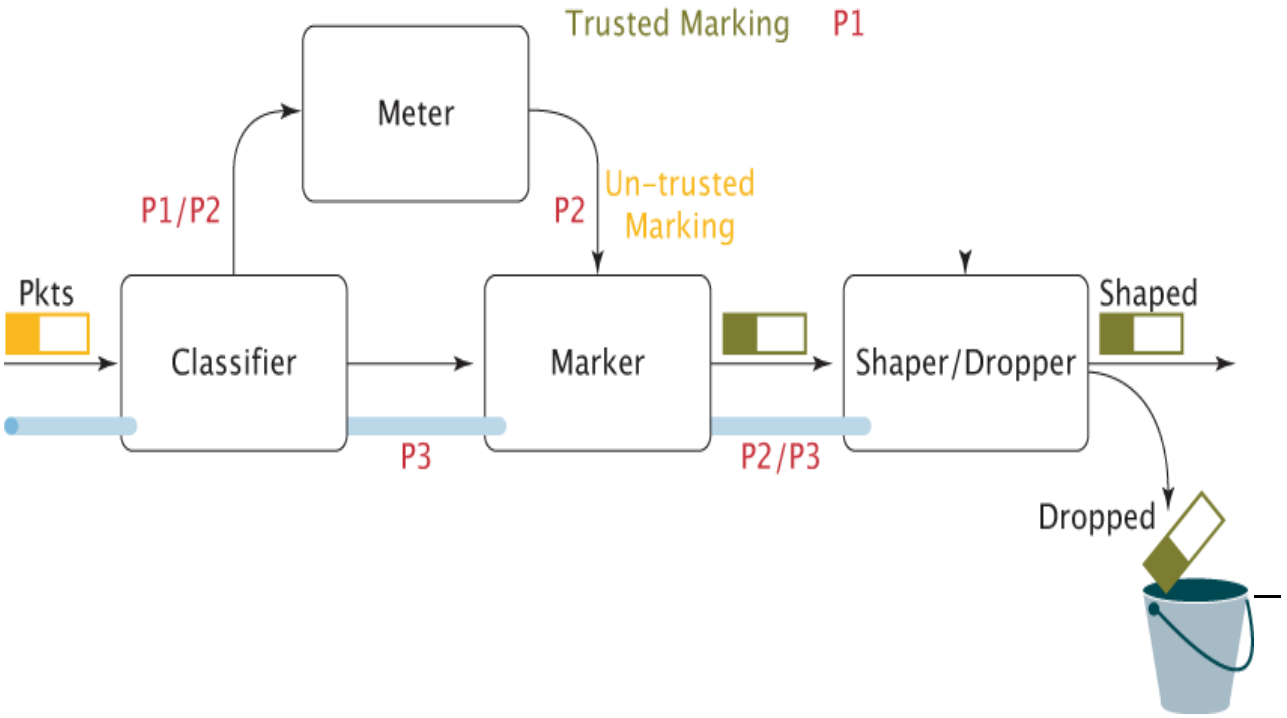
By keeping in view the following figures the implementation can be carried out.


Edge node
Edge node
Customer network
Interior node
Customer network
Interior node
Interior node
Edge node
Edge node
Customer network
Customer network
DiffServ
Domain B
DiffServ
Domain A
DiffServ
Domain C
DS – Ingress/Egress Node
DS – Boundary Node
TCB
Process
Premium
Gold
Silver
Bronze
Policer, Shaper, LLQ, WRED
Clarification & Marking
Packet "Color" in DSCP
PHB, WRED
LLQ, CBWFQ

A DS-domain is made up of DS ingress nodes, DS interior nodes (in the core), and DS egress nodes. An ingress or egress node will be a DS boundary node, connecting two DS domains together. All DS ingress and egress nodes can be marked as a boundary nodes, since these will act as a demarcation point between the DS-domain and the non-DS-aware network.

In this example the DS boundary node performs traffic conditioning . A traffic conditioner typically classifies the incoming packets into pre-defined aggregates, meters them to determine compliance to traffic parameters (and determines if the packet is in profile, or out of profile), marks them appropriately by writing/re-writing the DSCP value , and shapes (buffers to achieve a target flow rate) or drops the packet in case of congestion.

The following figure will illustrate the typical traffic conditioner at the edge of a DS-domain. A DS Internal node enforces the appropriate PHB by employing policing or shaping techniques, and sometimes re-marking out of profile packets, depending on the policy or the SLA.



Traffic conditioning (traffic policing and traffic shaping)—Traffic conditioning is performed at the edges of a DiffServ domain. Traffic conditioners perform traffic shaping and policing functions to ensure that traffic entering the DiffServ domain conforms to the rules specified by the Traffic Conditioning Agreement (TCA) and complies with the service provisioning policy of the domain. Traffic conditioning may range from simple code point re-marking to complex policing and shaping operations.

Packet classification—Packet classification uses a traffic descriptor (for example, the DSCP) to categorize a packet or a traffic stream within a specific group in order to define that packet. After the packet has been defined (that is, classified), the packet is accessible for QoS handling on the network.Using packet classification, we can partition network traffic into multiple priority levels or classes of service. When traffic descriptors are used to classify traffic, the source agrees to adhere to the contracted terms and the network promises a QoS. Traffic policers and traffic shapers use the traffic descriptor of the packet (that is, the classification of the packet) to ensure adherence to that agreement. The multi-field classifiers (MF) are based on the followings:

source destination address , source destination ports
protocol id and DSCP

Meter: Checks compliance to traffic parameters (ie: token bucket) and passes results to the marker and shaper/dropper to trigger action for in/out-of-profile packets.

Packet marking—Packet marking is related to packet classification. Packet marking allows you to classify a packet based on a specific traffic descriptor (such as the DSCP value). This classification can then be used to apply user-defined differentiated services to the packet and to associate a packet with a local QoS group. Associating a packet with a local QoS group allows users to associate a group ID with a packet. The group ID can be used to classify packets into QoS groups based on prefix, autonomous system, and community string. A user can set up to 64 DSCP values and 100 QoS group markings. A marker sets the DS field of a packet to a particular code point (DSCP value),

adding the marked packet to a particular DS behavior aggregate. There are two types of markers:

Single Rate Two Color Marker (srTCM) – It meters an IP packet stream and marks its packets green, yellow, or red. A packet is marked green if it doesn't exceed the CBS, yellow if it does exceed the CBS but not the EBS, and red otherwise. Metering is done when Expedite Forwarding PHB is desired and it has three parameters:

Committed Information Size (CIR)
Committed Burst Size (CBC)
Excess Burst Size (EBS)

Two Rate Three Color Marker (trTCM) – This is a three drop precedence scheme. It marks its packets based on two rates:

Peak Information Rate (PIR) and the
Committed Information Rate (CIR) and on their associated burst sizes
Peak Burst Size (PBS) and the
Committed Burst Size (CBS) respectively.

A packet is marked red if it exceeds the PIR, otherwise it is marked yellow or green depending on whether it exceeds or doesn’t exceed the CIR. The two meters of the trTCM use token buckets with parameters (CIR, CBS) and (PIR, PBS).

Shaper (Dropper): Delays some packets to be compliant with the profile.

4. OBJECTIVES

The WiMAX network was designed with QoS is mind, the aim of this research project is to identify and analyze the QoS with the help of various scheduling or queuing disciplines that are implemented by the WiMAX network for various discrete and priority based applications.

- Brief understanding of QoS requirements of WiMAX network.
- Identify QoS architecture of integrating different types of data applications.
- Understanding and investigating on various transmission technologies used to achieve better QoS.
- Understanding and analyzing of the parameters that indicates the quality of service like packet loss jitter, average delay, throughput etc.
- To design and evaluate the scheduling discipline to provide quality of service in WiMAX networking environment.
- To perform the simulation of scheduling disciplines for analyzing the QoS parameters using differentiated service components in WiMAX network.

5. STATE –OF –ART

It has been an unique tremendous growth in different areas of WiMAX networks. So there is an utmost necessity to provide better services to meet the growing demand required without compromising the quality of service. As the IEEE 802.16 standard is emerging and nourishing ,QOS issues with Differentiated service architecture have been addressed by/in different RFC's and many papers. In this section a brief summary of current work in this field is presented.

Mohammed Dawood [1] describes about WiMAX and QOS in detail in his theoretical research.

Rohit A. Talwalker and Mohammad Ilyas [2] focuses on analysis of Quality of Service as implemented by the WiMAX networks. Different parameters that indicate QOS such as throughput, packet loss, average jitter and average delay are analyzed by using ns-2 simulator.

RFC 2475[3] defines an architecture for implementing scalable service service differentiation in the Internet. It defines a number of functional elements

implemented in network nodes, including a small set of per-hop-forwarding behaviors, packet classification functions and traffic conditioning functions including metering, marking, shaping and policing.

RFC 2597[4] defines a general use Differentiated Service (DS) Per-Hop - Behavior(PHB) group called Assured Forwarding (AF).

RFC 3086[5] defines and discusses Per-Domain Behaviors in detail and lays out the format and required content for contributions to Diffserv on Per Domain Behaviors and the procedure that will be applied for individual PDB specifications.

RFC 3246[6] defines a PHB called Expedited Forwarding (EF).The PHB is the building block in DS architecture. EF is intended to provide a building block for low delay, low jitter and low loss services.

RFC 4594[7] describes service classes configured with Diffserv and recommends how they can used and how to construct them using DSCP's , traffic conditioners , Per-Hop Behaviors and Active Queue Management (AQM) mechanisms.

Volker Sander and Markus Fidler [8] describes the implementation of a network providing advanced services such as Premium Service (EF) that aims at low loss, low delay and low delay jitter and an Olympic Service(AF) service that allows for a a service differentiation in terms of delay within three additional classes.

Mei Yang, Enyue Lu and S.Qzheng [9] describes the dynamic diffserv scheduling algorithm(DDS) for dynamic bandwidth allocation for diffserv classes. In this paper DDS is to schedule EF and AF traffic according to their minimum service rates with reserved bandwidth and scheduled AF and BE traffic fairly with excess bandwidth.

Lan Wang, G.Min, D. Kouvatson and X.Jin [10] used the hybrid scheduling mechanisms which combines various scheduling principles like Priority Queuing (PQ), Earliest Deadline First (EDF), Weighted Fair Queuing (WFQ) and Round Robin (RR). They derived the expression for the performance matrices including the

mean no. of packets in the queue, throughput, mean queuing delay, packet loss probability and fairness of individual traffic flows.

Maria – Dolores Cano, Fernando Cerdan [11] introduced a new approach for traffic conditioning based on feedback signaling among boundary nodes and traffic conditioners by using Assured Forwarding PHB.

J.S. Li and C. S. Mao [12] describes the flowbased WFQ scheduler for providing flow based proportional differentiated services in a class-based diffserv router.

Data sheet from Cisco IOS Software : Quality of Service [13] describes the differentiated services model in detail including DSCP values and use of DSCP values in EF and AF PHB.

Bagio Budiardjo, B. Nazief and D Hartanto [14] proposed the algorithm for forwarding packets from guaranteed class-of-service into Expedited Forwarding PHB.

Li Zhu and Nirwan Ansari [15] proposed a network assist packet marking scheme to offer fair bandwidth allocation for Assured Forwarding (AF) services.

White Paper [16] from Intel Information Technology described about the QoS and the Class based weighted fair queuing (CBWFQ).

Rafal stankiewicz , Andrzeg Jajszczyk [17]proposed a model consists of Single Rate Three Color Marker, Two rate Three Color Marker , Time Sliding Window Three Color Marker and two types of droppers i.e. Weighted RED and RED with In/Out and coupled Virtual Queues used in AF PHB and EF PHB.

Kazumi Kumazoe , Yoshiaki H. ,T. Ikenaga , Y. Oie [18] investigated the throughput characterstics of end-to-end flows over multiple Diffserv domains to attain QOS performance.

Davide Adami, S. Giordano, and M. Rapati [19]used a experimental study on EF PHB service in Diffserv high speed network to create low loss, low latency and Assured bandwidth services.

Sangkil Jung, Jaiseung Kwak and Okhwan Byeon [20] have implemented the AF and EF PHB's by using several queue scheduling mechanisms such as WRR, PRR and PWRR to gratify the delay, jitter and throughput.

Ming-Jye Sheng , Kun I. Park and Thomas Mak [21] provides stochastic models for adaptive WRED and CBWFQ algorithms to analyze delay and throughput of each DSCP flow of a DSCP plan to support end-to-end QOS interoperability.

Dekeris B. Adomkus and T. Budnikas A. [22] used WFQ and LLQ both as in times of congestion WFQ is not capable to implement Diffserv so both scheduling disciplines to ensure QOS for high priority bursty video conferencing , Voice and data Services at the same time.

Denise M.B. Masi, Martin J. Fisscher and David A. Garbin [23] used LLQ and CBWFQ combined in which LLQ is related with tight delay constraints for real time traffic where as CBWFQ is used to ensure acceptable throughput for traffic classes that are less sensitive to delay.

Fischer M.J., Masi D. and Shortle J.F.[24] presented and discussed the critical role simulation has played in development of performance analysis tools for the CBWFQ discipline.

Juliana Freitag and Nelson L.S. da Fonseca [25] presents the design and validation of an WiMAX module developed for the ns-2 simulator release 2.28 based on specifications of the IEEE 802.16 standard.

6. Research Methodology

Research Challenges

Scheduling algorithms serve as an important component in any communication network to satisfy the QoS requirements. The design is especially challenged by the limited capacity and dynamic channel status that are inherent in wireless communication systems.

Bandwidth utilization

Efficient bandwidth utilization is the most important in the algorithm design. The algorithm must utilize the channel efficiently. This implies that the scheduler should not assign a transmission slot to a connection with a currently bad link.

QoS requirements

The proposed algorithm should support different applications to exploit better QoS.

To support delay-sensitive applications, the algorithm provides the delay bound provisioning. The long-term throughput should be guaranteed for all connections when the sufficient bandwidth is provided.

Fairness

The algorithm should assign available resource fairly across connections. The fairness should be provided for both short term and long term.

Implementation complexity

In a high-speed network, the scheduling decision making process must be completed very rapidly, and the reconfiguration process in response to any network state variation. Therefore, the amount of time available to the scheduler is limited. A low-complexity algorithm is necessary.

Scalability

The algorithm should operate efficiently as the number of connections or users sharing the channel increases.

Scheduling or Queuing Disciplines:

Scheduler or queuing—Queuing can be accomplished in different ways on different methods:

First In First Out (FIFO) Queuing

Deficit Round-Robin (DRR) and Modified Deficit Round Robin (MDRR)

It can handle packets of variable size without knowing their mean size. A maximum packet size number is subtracted from the packet length, and packets that exceed that number are held back until the next visit of the scheduler. WRR serves every nonempty queue whereas DRR serves packets at the head of every nonempty queue which deficit counter is greater than the packet's size. If it is lower then deficit counter is increased by some given value called quantum. Deficit counter is decreased by the size of packets being served.

Weighted Round-Robin (WRR)

It is the simplest approximation of GPS (Generalized Processor Sharing) and it gives weights to every data stream and those with higher weights are sent sooner. It has to have knowledge of the packet size

Deficit Round-Robin (DRR)

It can handle packets of variable size without knowing their mean size. A maximum packet size number is subtracted from the packet length, and packets that exceed that number are held back until the next visit of the scheduler. WRR serves every nonempty queue whereas DRR serves packets at the head of every nonempty queue which deficit counter is greater than the packet's size. If it is lower then deficit counter is increased by some given value called quantum. Deficit counter is decreased by the size of packets being served

Strict Priority (SP)

Each scheduler queue is randomly given 1 of 8 priorities with no minimum guarantees. All of the non-empty scheduler queues within each priority are FIFO and low priority queues can be starved. Whenever the outgoing link is available for a new packet, the highest priority queue is examined. If there is a packet ready to be sent out in this queue, it is selected. Otherwise, the next most important queue is examined, and so on, until the highest priority packet is found. The most obvious problem with strict priority is that low priority queues can be starved out and not allowed to send any packets. As long as higher priority packets arrive faster than the outgoing link send packets, no lower priority packets will be sent out. It is also impossible to create traffic profiles, which combine both latency and bandwidth, since only one metric, the packet priority, is available.

Weighted Fair queuing (WFQ)

WFQ is the basis for a class of queue scheduling disciplines that are designed to address limitations of FQ model.WFQ supports flows with different bandwidth reeuirements by giving each queue a weight that assigns it a different percentage of output port bandwidth.

WFQ also supports variable length packets, so that flow with larger packets are not allocated more bandwidth then flows with smaller packets. Supporting the fair

allocation of bandwidth when forwarding variable length packets adds significantly to the computational complexity of the queue scheduling algorithm which is easier to implement in fixed length networks.

Class-Based Weighted Fair Queuing(CBWFQ)

CBWFQ extends the standard WFQ functionality to provide support for user-defined traffic classes. For CBWFQ, we define traffic classes based on match criteria including protocols, access control lists (ACLs), and input interfaces. Packets satisfying the match criteria for a class constitute the traffic for that class. A FIFO queue is reserved for each class, and traffic belonging to a class is directed to the queue for that class. Once a class has been defined according to its match criteria, we can assign it characteristics. To characterize a class, you assign it bandwidth, weight, and maximum packet limit. The bandwidth assigned to a class is the guaranteed bandwidth delivered to the class during congestion.

To characterize a class, we also specify the queue limit for that class, which is the maximum number of packets allowed to accumulate in the queue for the class.

Packets belonging to a class are subject to the bandwidth and queue limits that characterize the class. After a queue has reached its configured queue limit, enqueueing of additional packets to the class causes tail drop or packet drop to take effect, depending on how class policy is configured. Tail drop is used for CBWFQ classes unless we explicitly configure policy for a class to use WRED to drop packets as a means of avoiding congestion. Note that if you use WRED packet drop instead of tail drop for one or more classes comprising a policy map, you must ensure that WRED is not configured for the interface to which we attach that service policy.

If a default class is configured with the bandwidth policy-map class configuration , all unclassified traffic is put into a single FIFO queue and given treatment according to the configured bandwidth. If a default class is configured with the fair-queue , all unclassified traffic is flow classified and given best-effort treatment. If no default class is configured, then by default the traffic that does not match any of the configured classes is flow classified and given best-effort treatment. Once a packet is classified, all of the

standard mechanisms that can be used to differentiate service among the classes apply. Flow classification is standard WFQ treatment. That is, packets with the same source IP address, destination IP address, source TCP or UDP port, or destination TCP or UDP port are classified as belonging to the same flow. WFQ allocates an equal share of bandwidth to each flow. Flow-based WFQ is also called fair queueing because all flows are equally weighted. For CBWFQ, the weight specified for the class becomes the weight of each packet that meets the match criteria of the class. Packets that arrive at the output interface are classified according to the match criteria filters you define, then each one is assigned the appropriate weight. The weight for a packet belonging to a specific class is derived from the bandwidth you assigned to the class when we configured it; in this sense the weight for a class is user-configurable.

After the weight for a packet is assigned, the packet is enqueued in the appropriate class queue. CBWFQ uses the weights assigned to the queued packets to ensure that the class queue is serviced fairly.

Configuring a class policy—thus, configuring CBWFQ—entails these three processes:

Defining traffic classes to specify the classification policy (class maps). This process determines how many types of packets are to be differentiated from one another. Associating policies—that is, class characteristics—with each traffic class (policy maps). This process entails configuration of policies to be applied to packets belonging to one of the classes previously defined through a class map. For this process, we configure a policy map that specifies the policy for each traffic class.

Attaching policies to interfaces (service policies). This process requires that we associate an existing policy map, or service policy, with an interface to apply the particular set of policies for the map to that interface.

Why Use CBWFQ?

Here are some general factors we should consider in determining whether we need to configure CBWFQ:

Bandwidth allocation

CBWFQ allows us to specify the exact amount of bandwidth to be allocated for a specific class of traffic. Taking into account available bandwidth on the interface, we can configure up to 64 classes and control distribution among them, which is not the case with flow-based WFQ. Flow-based WFQ applies weights to traffic to classify it into conversations and determine how much bandwidth each conversation is allowed relative to other conversations. For flow-based WFQ, these weights, and traffic classification, are dependent on and limited to the seven IP Precedence levels.

Coarser granularity and scalability

CBWFQ allows to define what constitutes a class based on criteria that exceed the confines of flow. CBWFQ allows us to use ACLs and protocols or input interface names to define how traffic will be classified, thereby providing coarser granularity. We need not maintain traffic classification on a flow basis. Moreover, we can configure up to 64 discrete classes in a service policy.

Low Latency Queueing

The LLQ feature brings strict PQ to CBWFQ. Strict PQ allows delay-sensitive data such as voice to be dequeued and sent before packets in other queues are dequeued.

Without LLQ, CBWFQ provides WFQ based on defined classes with no strict priority queue available for real-time traffic. CBWFQ allows us to define traffic classes and then assign characteristics to that class. For example, we can designate the minimum bandwidth delivered to the class during congestion. For CBWFQ, the weight for a packet belonging to a specific class is derived from the bandwidth we assigned to the class when we configured it. Therefore, the bandwidth assigned to the packets of a class determines the order in which packets are sent. All packets are serviced fairly based on weight; no class of packets may be granted strict priority. This scheme poses problems for voice traffic that is largely intolerant of delay, especially variation in delay. For voice traffic, variations in delay introduce irregularities of transmission manifesting as jitter in the heard conversation. LLQ provides strict priority queueing for CBWFQ, reducing jitter in voice conversations. Configured by the priority feature, LLQ enables use of a single, strict priority queue within CBWFQ at the class level, allowing to direct

traffic belonging to a class to the CBWFQ strict priority queue. Within a policy map, we can give one or more classes priority status. When multiple classes within a single policy map are configured as priority classes, all traffic from these classes is enqueued to the same, single, strict priority queue. One of the ways in which the strict PQ used within CBWFQ differs from its use outside CBWFQ is in the parameters it takes. We are no longer limited to a UDP port number to stipulate priority flows because we can configure the priority status for a class within CBWFQ. Instead, all of the valid match criteria used to specify traffic for a class now apply to priority traffic. These methods of specifying traffic for a class include matching on access lists, protocols, and input interfaces. Moreover, within an access list we can specify that traffic matches are allowed based on the IP differentiated services code point (DSCP) value that is set using the first six bits of the ToS byte in the IP header. Although it is possible to enqueue various types of real-time traffic to the strict priority queue, we strongly recommend that we direct only voice traffic to it because voice traffic is well-behaved, whereas other types of real-time traffic are not. Moreover, voice traffic requires that delay be non variable in order to avoid jitter. Real-time traffic such as video could introduce variation in delay, thereby thwarting the steadiness of delay required for successful voice traffic transmission.

Proposed Tool to be used:

Network Simulator ns2

Network simulator ns2 is an eventdriven network simulator used for networking research. It is a widely used tool for simulating internetwork topologies to test and evaluate various networking protocols. There is a substantial support and flexibility in ns2 to simulate various traffic generation patterns, routing and multicast protocols. In order to study different networking issues like protocol interaction, congestion control, effect of network dynamics, scalability etc. it is necessary to simulate various scenarios that include different topology sizes, density distribution, traffic generation, membership distribution, realtime variance of membership, network dynamics etc. The ns2 scenario generator can be used to create different random scenarios for simulation. In ns2, characteristics of

physical media of communication like delay, bandwidth, error rate, antennas and wireless physical interface parameters etc. can be defined. This helps in
making the simulation studies as close to realistic scenarios as possible. ns2 provides the flexibility to add and experiment new protocols or ideas. Recently, much support has been added for simulating wireless networks and interconnecting wired and wireless networks. Trace support in ns2 may be used to trace packets for wireless and wired scenarios.

7. SIGNIFICANCE

By using the Implementation of DiffServ for End-to-End Quality of Service in WiMAX feature set to implement the Differentiated Services architecture. The benefits of implementing Differentiated Services include the following:

- Reduces the burden on network devices and easily scales as the network grows.
- Allows customers to keep any existing Layer 3 ToS prioritization scheme that may be in use.
- Allows customers to mix DiffServ-compliant devices with any existing ToS-enabled equipment in use.
- Alleviates bottlenecks through efficient management of current corporate network resources.

8. REFERENCES

[1] ECOM 5301 Senior I, Theoretical Research about : WiMAX and QoS by Mohammed Dawood.

[2] Rohit A. Talwalkar , Mohammad ILyas, ‘’ Analysis of Quality of Service (QoS) in WiMAX networks

[3] S. Blake, D. Black, M. Carlson,E.Davles,Z.Wang,W.Weiss “An Architecture for Differentiated Services”, RFC 2475,December 1998

[4] J.Heinanen, F. Baker, W.Weiss, J. Wroclawski " Assured Forwarding PHB Group",RFC2597,June 1999

[5] K. Nicholas, B. Carpenter "Definition of Differentiated Services Per Domain Behaviors and Rules for their Specification", RFC 3086, April 2001

[6] B. Davie, A.Charny, J.C.R. Bennett,K. Benson, J.Y. Le Boudec, W. Courtney, S. Davari, V. Firoiu, D. Stiliadis " An Expedited Forwarding PHB (Per-Hop-Behavior)", RFC 3246 , March 2002

[7] J. Babiarz, K. Chan, F.Baker "Configuration Guidelines for Diffserv Service Classes",RFC 4594, August 2006

[8] Volker Sander, Markus Fidler "Evaluation of a Differentiated Services Based Implementation of a Premium and an Olympic Service" QofIS/ICQT 2002,LNCS 2511,PP 36-46,2002.

[9] Mei Yang, Enyue Lu, S.Q. Zheng " Scheduling with Dynamic Bandwidth Allocation for Diffserv Classes", The 12th International Conference on Computer Communication and Networks,2003,ICCH 2003 Proceedings ,Pages 319-324

[10] Lan Wang, Geyong Min, Demetres Kouvatsos, Xiaolong Jin "An Analytical Model for the Hybrid PQ-WFQ Scheduling for WiMAX Networks" , Ist International Wireless VITAE -2009,Pages 492-498

[11] Maria-Dolores Cano, Fernando Cerdan " Proportional Bandwidth Distribution in IP Networks Implementing the Assured Forwarding PHB ", 10th IEEE Symposium on Computers and Communications -2005,Pages 833-839

[12] J.S. Li , C.S. Mao " Providing flow based proportional differentiated services in class-based Diffserv routers ", IEEE Proceedings in Communication, Vol 151 no 1,Feb 2004, Pages 82-88

[13] Data Sheet from Cisco " Cisco IOS Software: Quality-of-Service -The Differentiated Service Model(DiffServ)"

[14] Budiardjo B,Nazief B, Hartanto D,"Integrated Services to Differentiated Services packet forwarding: guaranteed service to expedited forwarding PHB",25th Annual IEEE Conference on Local Computer networks,Nov 2000,pages 324-325.

[15] Li Zhu, Nirwan Ansari "Fair Bandwidth Allocation for Assured Forwarding (AF) Services"IEEE International Conference ,ICC 2005,Vol 1,August 2005,Pages 374-378

[16] White Paper [16] from Intel Information Technology described about the QoS and the Class based weighted fair queuing (CBWFQ).

[17] Rafal Stankiewicz , Andrzej Jajszczyk , "Modular Model Based Performance Evaluation of a Diffserv Network Supporting Assured Forwarding PHB",IEEE Conference on Communications 2004,vol 4,pages 2071-2075

[18] Kazumi Kumazoe, Yoshiaki Hori, Takeshi Ikenaga, Yuji Oie," Quality of Assured Service Through Multiple Diffserv Domains",IEEE Pacific Rim Conference on Communications,Computers and signal processing,Aug 2001,vol1, pages 83-86.

[19] Davide Adami, Stefano Giordano, Matteo Repeti, Fedrico Orlandini,"An Experimental Study on the EF-PHB service in a Diffserv High Speed Network",IEEE International Conference on Communications,year 2004,vol.2,pages 1263-1267.

[20] Sangkil Jung, Jaiseung Kwak, Okhwan Byeon ," Performance Analysis of Queue Scheduling Mechanisms for EF PHB and AF PHB in Diffserv Networks",5th International Conference on High Speed data networks and Multimedia Communication, Year 2002,pages 101-104.

[21] Ming-Jye Sheng, Kun I. Park, Thomas Mak," Analysis of adaptive WRED and CBWFQ Algorithms on Tactical Edge", IEEE Military Communication Conference 2008,MILCON 2008,pages 1-7.

[22] Brunonas Dekeris, Tomas Adomkus, Aurelijus Budnikas," Analysis of QoS Assurance using Weighted Fair Queueing(WFQ) Scheduling Discipline with Low Latency Queue(LLQ)",28th International Conference on Information Technology Interfaces 2006,Oct 2006,pages 507-512

[23] Denise M. Bevilacqua Masi, Martin J. Fisher, David A. Garbin," Modeling the Performance of Low Latency Queueing for Emergency Telecommunications", Proceedings of the Winter Simulation Conference Dec 2007,pages 2266-2275

[24] Martin J. Fischer, Denise M. Bevilacqua Masi, John F. Shortle," Simulating the Performance of a Class-Based Weighted Fair Queueing System", Proceedings of the Winter Simulation Conference Dec 2008,pages 2901-2908

[25] Juliana Freitag, Nelson L.S. da Fonseca," WiMAX Module for the NS-2 Simulator",18th Annual International Symposium on Personal,indoor and Mobile Radio Communications,Year2007, pages 1-6.

[26] Brahim Bensaou, Shixin Zhuang, Xiren Cao," Statistical Bounds on the Drop Probability of Assured Forwarding Services in Diffserv Nodes under the Processor Sharing Scheduling Discipline",IEEE International Conference on Performance, Computing and Communications, year 2004,pages 223-230.

[27] Sladania Zoric, Melika Bolic," Fairness of Scheduling algorithms for Real-time traffic in DiffServ based Networks",15th IEEE Mediterranean Electrotechnical Conference, MELCON 2010,April 2010,pages 1591-1596.

[28] White Paper from Shohei Sato, Kazutomo Kobayashi, Huanxu Pan, Sandra Tartarelli, Albert Banchs of NEC Corporation, NEC Europe Ltd.

[29] Giuseppe Bianchi, Nicola Blefari-Melazzi," Admission Control over Assured Forwarding PHBs :a way to provide service accuracy in a Diffserv framework",IEEE Global Telecommunications Conference,2001,vol 4, pages 2561-2565.

[30] Johan Karlsson, Ulf Bodin ,Andrej Brodnik, Andreas Nilsson, Olov Schelen," Extended Expedited Forwarding: the In-Time PHB group", 8th IEEE International Symposium on Digital Object Identifier,year 2003,vol1,pages 291-298.

[31] Pratik Dhrona, Najah Abu Ali, Hossam Hassanein, "A Performance Study of Scheduling Algorithms in Point-to-Multipoint WiMAX networks",33rd IEEE Conference on Local Computer Networks,Oct.2008,page 843-850.

[32] Mei Yang, Jianping Wang, Enyue Lu, S.Q. Zheng," Hierarchical Scheduling for Diffserv Classes",IEEE Global Telecommunications Conference, Dec.2004, vol.2, pages 707-712

[33] J.J. Smit, H.C. Ferreira ," Scheduler Performance Evaluation and the Effect of Aggregation on QOS in a Diffserv Enabled Network",7th AFRICON Conference 2004, Sept 2004,vol 1,pages 323-328

[34] Peng Yi, Hongchao Hu, Binqiang Wang, Hui Li, " PMUF: A High Performance Scheduling Algorithm for Diffserv Classes",IEEE International Joint Conference on Computational Sciences and Optimization,April 2009,vol.1,pages 344-350.

[35] Ahmed H. Rashwan, Hesham M. ElBadawy, Hazem H. Ali," Comparative Assessments for Different WiMAX Scheduling Algorithms", World Congress on Engineering and Computer Science Proceedings 2009, Oct 2009,vol 1.

[36] K.Nichols, V.Jacobson, L.Zhang, "A Two-bit Differentiated Services Architecture for the Internet", Internet Draft, April 1999

[37] "Introduction to Quality of Service" Expert Reference Series Of White Papers from Global Knowledge.

[38] "Quality of Service Design Overview" from Enterprises QOS Solution References network Design Guide version 3.3 from CISCO Systems

[39] White Paper " Diffserv- The scalable End-To-End Quality of Service Model ", from CISCO Systems

[40] Chuck Semeria ," Supporting Differentiated Service Classes: Queue Scheduling Disciplines" ,White Paper 2000.

[41] Sasan Abidi ," A Survey of QoS Best Practice White Paper", Oct 2007, WiMAX Forum.